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Combined Geothermal Heat and Power Generation

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Keywords

Geothermal, Combined heat and power (CHP) plants, Binary or Organic Rankine Cycle (ORC)

Abstract

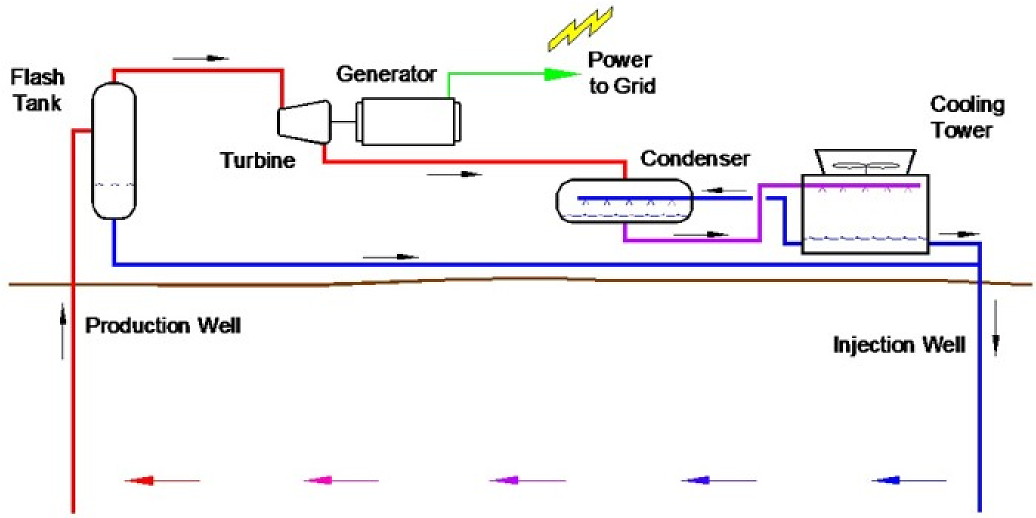
Deep geothermal energy has high potential. How the geothermal resource under the surface of the earth can be efficiently used depends on the temperature and flow rate (in case of geothermal water) of the geothermal resource. For the use of geothermal energy a distinction is made between electricity generation and direct use in a geothermal power plant. Electricity production is dominated by high-enthalpy resources. With special technologies like ORC or Kalina-Cycle the low and medium temperature resources can also be used for electricity production. Direct application for heating is far more efficient than electricity generation and has less demanding temperature requirements. Heat may either come directly as direct use from the geothermal resources over a geothermal heat plant or from co-generation with a geothermal electrical plant. Co-generation means the use of the geothermal resource for multi-purposes in order to increase the efficiency of the geothermal energy exploitation.

State of the art

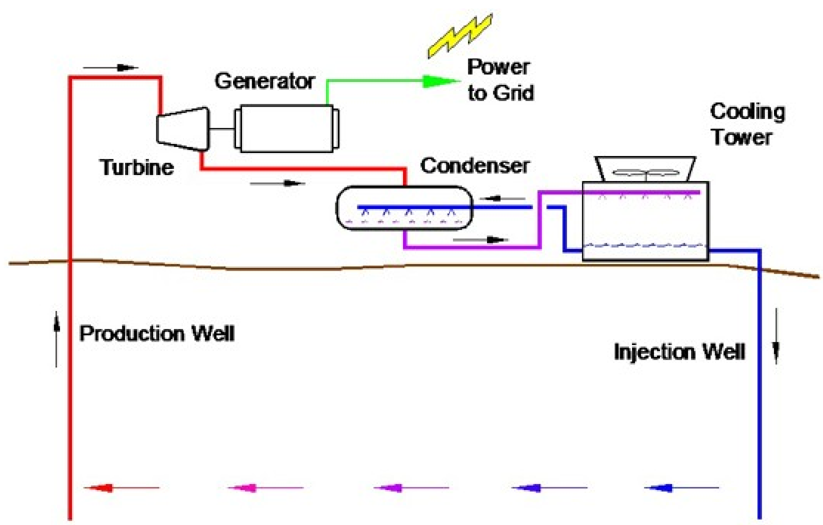
Geothermal cogeneration also named as combined heat and power (CHP) means the simultaneous generation of more than one useful form of geothermal energy. In a geothermal cogeneration system the geothermal resource is decoupled for simultaneously using it for electricity-production, heating purposes and direct uses like greenhouses. For direct uses the supplied utilities have to be very close to the plant. The cascading use of energy from high-to low-temperature makes cogeneration more efficient than separate geothermal systems for electricity and heat production. From the viewpoint of optimization of efficiencies combined heat and power (CHP) is optimal.

The geothermal plants for electricity generation can work on several technologies:

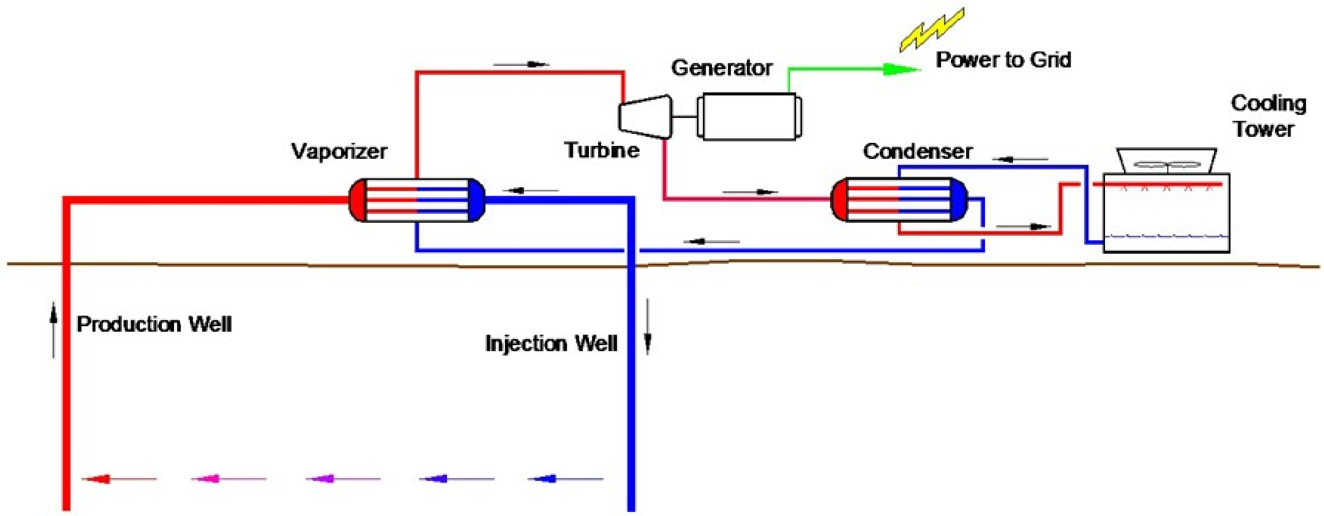
- Flash steam plants use hot pressurised water with temperature of above 180 °C. The hot water is pumped under great pressure to the surface. When it reaches the surface the pressure decreases to the stage it vaporises. This leads to a two-phase water -steam mixture and a vapour lift process. The steam drives a turbo-alternator for electricity production.



- Dry steam plants use hydrothermal fluids that are primarily steam and emerge at the earths surface. The steam goes directly to a turbine, which drives a generator that produces electricity.



- Binary plants extract energy from geothermal fluids of about 75 ° to 180 °C. Hot geothermal fluid and a binary fluid with a much lower boiling point than the geothermal water pass through a heat exchanger. Heat from the geothermal fluid causes the binary fluid to flash to vapour. The vapour drives the turbines.



Attached to the electricity generation plant a heating system is attached. Part of the geothermal resource is decoupled to the heating plant/system and direct use applications.
Currently cogeneration is trending towards increased efficiencies in order to optimize the power generation of CHP plants. Moderate-temperature water between 75 ° and 180 °C is by far the most common geothermal resource. This will lead to the fact that especially in a steadily increasing geothermal technology environment the share of binary cycle plants will increase.
The steady improvement of Enhanced Geothermal Systems (EGS) technology is expected to significantly widen the spectrum of geothermal CHP.

Geothermal solution

Geothermal CHP plants offer the opportunity to combine electricity generation with direct heat applications. The utilization for direct heat applications can be accomplished using the thermal energy available in a waste brine and rejected heat in a condenser to heat fresh water, which can then be distributed to a variety of end users. The technical feasibility and design of such co-generation power plants depend on a number of factors, including the reservoir temperature of the geothermal fluid, the type of flash system used in the power plant, the distance to end users and the types of applications.

The principal technical advantage of geothermal cogeneration systems is their ability to improve the efficiency of geothermal energy use in the production of electrical and thermal energy what improves the economics of the entire system.

Many CHP plants, especially those using a low-temperature resource, started as district heating project. The electric power plant was later added, and became economical, as the well and pumping systems were already in place. Nowadays the CHP is in most cases more profitable and efficient than separate geothermal solutions for electricity generation and direct use.

Compared to conventional power plants on electricity production and district heating, the technical advantages of cogeneration out of geothermal energy lead to significant environmental advantages. The increase in efficiency and non-use of fuel use by the geothermal cogeneration system, compared to separate processes for thermal and electrical energy production, lead to large reductions in environmental emissions.

Geothermal cogeneration is not the end of the process. The by-product heat at moderate temperatures (100-180°C) can also be used in absorption chillers for cooling. This offers the possibility of a polygeneration plant, producing electricity, heat and cold. Cogeneration is a proven technology. Polygeneration is the next step.

Advantages against other applications

- Cogeneration technology provides greater conversion efficiencies than traditional generation methods as it cascades the geothermal heat for different applications and though increases the use and exploitation of the geothermal resource

- A geothermal co-generation plant compared to separate processes for geothermal heat and electricity production increases the profitability of the system

- Reduction of greenhouse gases compared to conventional power plants on electricity production and district heating

Conclusion

The main conclusion of this paper is that the economy of a binary power plant depends highly on the characteristics of the geothermal area, i.e. temperature and flowrate. Binary technology is feasible for the production of electricity from geothermal resources at temperatures 120° and up. However plants may be viable for temperature down to 75°C if the circumstances are favorable.

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